ISOTOPE AND TRACK PRODUCTION IN METEORITES AND COSMIC RAY VARIATIONS.

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Simultaneous measurements of several cosmic ray effects such as VH track density, spallogenic ^{26}Al and ^{53}Mn activity and ^{21}Ne and $^{22}Ne/^{21}Ne$ (NeR) ratio made in the same aliquot or in cores taken across a chondrite can be used to identify parameters which are related to single or multiple exposure of the meteorite and cosmic ray variations. Fig. 1 shows the ^{26}Al, ^{53}Mn, ^{21}Ne and NeR profiles as a function of shielding depth in three meteorites St. Severin (LL), Keyes (L) and Dhajala (H) known to have preatmospheric radius of about 25, 30 and 50 cms. respectively. The shielding depths were calculated from the track density profiles which are also shown in this figure. Based on this figure and other data [1-3] we adopt average production rates ^{26}Al : ^{53}Mn : ^{21}Ne = 60dpm/kg met : 415dpm/kg Fe : 0.39×10^{-8}cc/g.my in chondrites. A three isotope correlation diagram ($^{21}Ne/^{26}Al$ vs $^{21}Ne/^{53}Mn$) is proposed as shown in fig. 2 which can be used to determine variations in cosmic ray flux over 10^6-10^7 yr period. Curves for plausible variations in cosmic ray flux over various periods of time T_1 and T_2 (indicated by suffix to ϕ, in million years) have been constructed as shown in this figure. If the cosmic ray flux increases with time eg. if flux during the past 2 m.y. is twice that existing earlier ($\phi_2 = 2\phi T_1$), the curve lies below that of constant flux $\phi T_1 = \phi T_2$. On the other hand if the flux has decreased with time to half during the past 2 m.y. as compared to before i.e. $\phi_2 = 0.5\phi T_1$ the points lie above the curve of constant flux. However, a meteorite records different fluxes not only as a consequence of genuine variation in cosmic ray energy spectrum but also when irradiation geometry changes due to fragmentation in space or ejection from asteroidal regolith. To distinguish these two cases we consider the track and isotope production characteristics which have different path lengths. The track and NeR data for several meteorites i.e. Akron (A), Barwell (B), Bruderheim (BR), Dhajala (D), Etter (E), Eva (Ev), Edmonson (Ed), Finney (F), Harrisonville (H), Keyes (K), Nogata (N), Roy (R), Shaw (Sh) and St. Severin (S) are plotted in fig. 3. Using the criterian discussed earlier [4] that for single stage exposure NeR and track density values should lie on the calculated curves, we find that only Barwell, Dhajala, Keyes, Shaw and St. Severin and possibly Eva have single stage exposure. If we consider only these meteorites the data in fig. 2 fall on the curve of nearly constant cosmic ray flux. Thus these data show that the cosmic ray flux has not varied in the past 10^6-10^7 yrs. The data which deviate from this curve belong to cases of multiple exposure as is clear from fig. 3.

Terrestrial ages of meteorites can also be determined using similar curves as shown in fig. 4 where data on antarctic meteorites are plotted. The figure indicates that their ages are $< 10^6$ yrs in conformity with other methods.

References:

[1] Nishiizumi K, Regnier S. and Marti K. (1980) Earth Planet Sci Lett. 50 150. [2] Muller O, Hampel W, Kristen T. and Herzog G.F. (1981) Geochim Cosmochim Acta 45, 447. [3] Herpers U. and Englert P. (1983) preprint. [4] Bhandari N. and Potdar M.B. (1982) Earth Planet Sci Lett. 58, 116.

Cosmic ray variations

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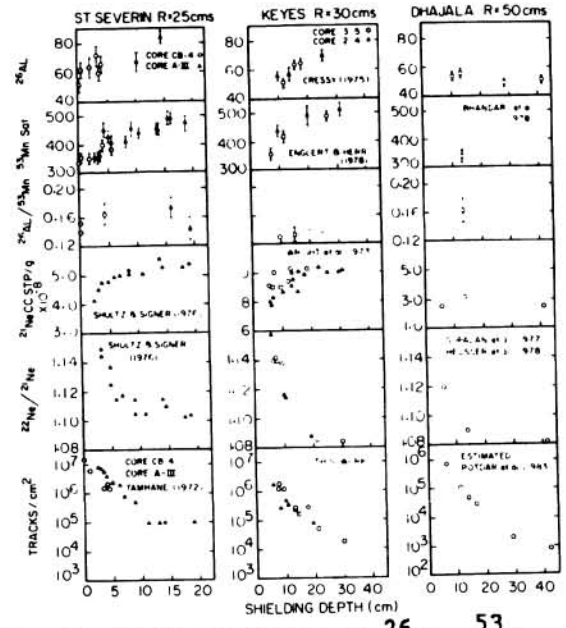

Fig. 1. Depth profiles of ^{26}Al, ^{53}Mn, ^{21}Ne and NeR in St. Severin, Keyes and Dhajala based on track density data also shown.

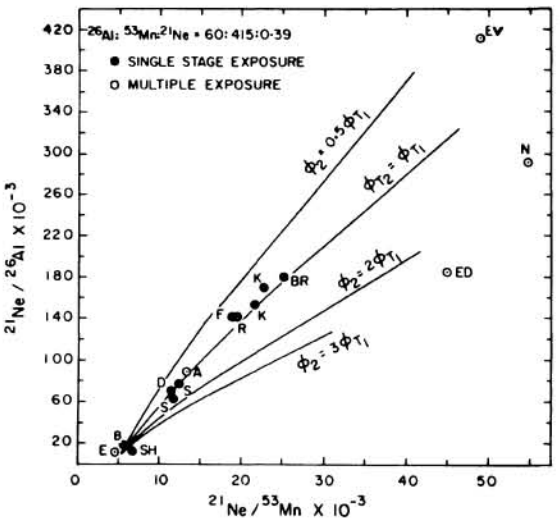

Fig. 2. $^{21}Ne/^{26}Al$ vs $^{21}Ne/^{53}Mn$ plot for different variations in cosmic ray flux ϕ. Experimental data for various meteorites are shown.

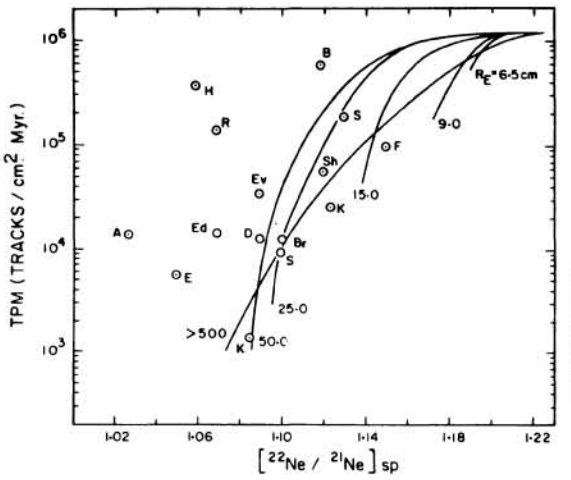

Fig. 3. Track production rate-NeR correlation diagram. Calculated curves and data points for various meteorites are shown.

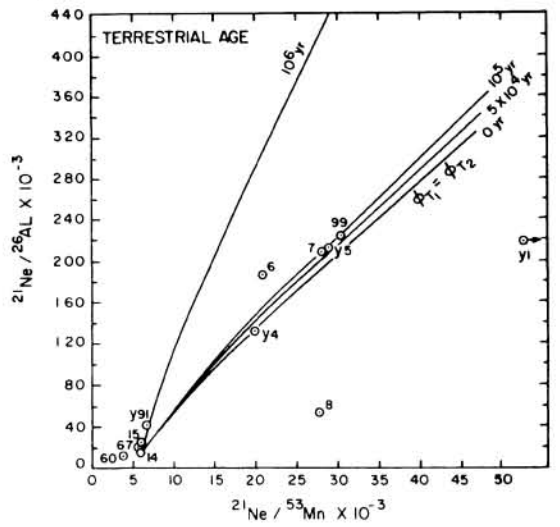

Fig. 4. Calculated curves for different terrestrial ages. Data points for some antarctic meteorites (identified by their last digit, Y for Yamato) are shown.